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Method, test strain and test kit for the laboratory diagnosis of neisseria gonorrhoeae.

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A strain of *Neisseria gonorrhoeae* ATCC 31953 is described which has characteristically poor growth on chocolate agar at a temperature range of about 30°C to about 37°C in a CO<sub>2</sub> atmosphere suitable for growth of *N. gonorrhoeae*. This strain is resistant to nalidixic acid at the 5-10 mcg/ml level and resistant to streptomycin at the 1000 mcg/ml level or greater. The strain is suitable for a method for the laboratory diagnosis of gonorrhea, comprising the steps of (1) preparing a test strain of the microorganism *Neisseria gonorrhoeae* which is competent for transformation, (2) extracting *N. gonorrhoeae* DNA from a patient's specimen material or colonies suspected of being *N. gonorrhoeae* whether in pure or mixed culture by treatment with a base which lyses *N. gonorrhoeae*, (3) adjusting the pH of the extract of step (2) to a pH that is not toxic to the test strain, (4) applying the pH adjusted extract to the test strain before or after putting it on or into a biological medium suitable for growth of *N. gonorrhoeae*, (5) maintaining the treated test strain at optimum *N. gonorrhoeae* growth conditions which are inhibitory for the test strain and (6) observing for detectable growth of the treated test strain. The observance of growth indicates detection of *N. gonorrhoeae* DNA. Also described is a test kit for performing the method.

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BRIEF SUMMARY OF THE INVENTION

15           The standard laboratory diagnosis of gonorrhea depends on isolation and subsequent identification of Neisseria gonorrhoeae by colony morphology, microscopic examination, biochemical or serologic tests (Kellog, Jr., et al., Laboratory Diagnosis of Gonorrhea, Cumitech, Amer. Soc. Microbiol., 1976). Although gram stain examination  
20 can be used to diagnose gonococcal urethritis, this technique lacks sensitivity in detecting infections of the cervix, rectum or oropharynx. Other diagnostic methods, such as serologic testing or direct fluorescent antibody  
25 staining, have not proven useful.

          Because N. gonorrhoeae loses viability rather quickly, the best procedure for isolating gonococci is to culture a specimen as soon as possible. This requires special facilities since it is necessary to incubate the  
30 inoculated culture media at 35°C-37°C in a CO<sub>2</sub> atmosphere. When proper facilities are not available, specimens can be sent to a laboratory in Amies' or Stuart's transport medium or in a transport and growth medium such as Transgrow (Martin, Lester, HSMHA Health  
35

1 rep. 86:30, 1971). The latter procedures are not nearly  
as good as immediate culturing which itself is about  
90-95% sensitive in detecting gonococci (Schmaly, Martin,  
Domescik, J.Am.Med. Assoc. 210:312, 1969; Caldwell, Price,  
5 Pazin, Cornelius, Am. J. Obstr. Gynecol. 109:463, 1971).

In 1976, a transformation test was reported which  
could be used to identify a clinical isolate as N.  
gonorrhoeae and thereby to help diagnose gonorrhea (Janik,  
Juni, Heym, J. Clin. Microbiol. 4:71; Juni U.S. Patent No.  
10 3,930,956). A transformation test depends on detecting  
gonococcal DNA as compared to a culture technique which  
depends on isolating colonies. In preliminary laboratory  
studies, the test appeared to be a useable alternative to  
standard procedures for identifying colonies of N.  
15 gonorrhoeae (Bawdon, Juni, Britt, J. Clin. Microbiol.  
5:108, 1977; Sarafian, Young, J. Med. Microbiol. 13:291,  
1980). However, in a field trial, done in collaboration  
with the Centers for Disease Control, using specimens  
obtained from clinic patients, the test described was  
20 found to be insensitive and nonspecific for the laboratory  
diagnosis of gonorrhea infections.

The Juni transformation test depends on DNA from  
gonococci in a colony or a specimen, to contain genes  
which can correct a nutritional deficiency of a test  
25 strain of N. gonorrhoeae, i.e. the test strain cannot grow  
on a special test medium unless it is given a particular  
nutrient. However, this strain can take up and  
incorporate gonococcal DNA (genes) into its genome, so  
that it is transformed with such genes and can now grow on  
30 the special test medium. If the gonococci of a colony, or  
in a specimen, and the test strain happened to have the  
same nutritional deficiency, then the test strain cannot  
be transformed to grow on the special test medium, thereby  
preventing detection of N. gonorrhoeae DNA from a colony  
35 or specimen. Since it is known that there is a variety of

0081078

1 nutritional variants of N. gonorrhoeae which infect humans  
(Crawford, Sex. Trans. Dis. 5:165, 1978), the Juni test  
obviously requires a battery of test strains with  
different nutritional deficiencies in order to cover the  
5 spectrum of possibilities in any one test situation.

The Juni test requires the use of two culture  
media, one of which is so specialized that it is not  
available in a routine diagnostic laboratory. The  
technique for extracting DNA calls for using surfactants  
10 such as sodium dodecyl sulfate at a concentration which is  
at the borderline level of toxicity for the test strains.  
This could negate potentially positive results. The  
transformation technique involves a preliminary incubation  
period of the DNA and the test strain, followed by a  
15 second step which involves subculturing the DNA-test  
strain mixture onto the specialized medium. After 24  
hours of incubation the results of their test are barely  
visible to the naked eye. One needs a microscope to  
detect the growth of colonies which indicates a positive  
20 result (Bawdon et al, J. Clin. Microbiol. 5:108, 1977).

The present invention relates to a novel test strain  
N. gonorrhoeae ATCC 31953, which when utilized in accordance  
with the novel method of this invention, enables an  
accurate laboratory diagnosis of gonorrhea to be made by  
25 detecting N. gonorrhoeae DNA. The test strain, N.  
gonorrhoeae ATCC 31953, has been deposited with the  
American Type Culture Collection, Rockville, MD, in accor-  
dance with Rule 28 EPC. This novel test strain barely grows  
30 in conditions considered to be optimum for N. gonorrhoeae  
and has certain antibiotic resistance genes introduced by  
genetic recombination.

The method of this invention comprises the steps  
of (1) preparing a test strain of the microorganism  
35 Neisseria gonorrhoeae which is competent for

1 transformation, (2) extracting N. gonorrhoeae DNA from a  
patient's specimen material or colonies suspected of being  
N. gonorrhoeae whether in pure or mixed culture by  
treatment with a base which lyses N. gonorrhoeae, (3)  
5 adjusting the pH of the extract of step (2) to a pH that  
is not toxic to the test strain, (4) applying the pH  
adjusted extract to the test strain before or after  
putting it on or into a biological medium suitable for  
growth of N. gonorrhoeae, (5) maintaining the treated test  
10 strain on or in a medium suitable for growth of N.  
gonorrhoeae at optimum N. gonorrhoeae growth conditions  
which are inhibitory for the test strain and (6) observing  
for detectable growth of the treated test strain. The  
observance of growth indicates positive detection of N.  
15 gonorrhoeae DNA.

In accordance with this invention a test kit is  
provided which enables the method of this invention to be  
performed, which kit includes a test strain of N.  
gonorrhoeae which grows poorly at about 36°C on or in a  
20 biological medium, and may optionally contain other  
components required to perform the test such as a  
biological medium capable of supporting growth of a test  
strain, a base, an acid, a pH indicator, and necessary  
laboratory equipment and supplies.

25 The novel method of this invention requires only  
one test strain. It depends on a genetic characteristic  
common to all N. gonorrhoeae causing human infections,  
namely, the ability to grow at about 36°C. The  
invention permits the use of such biological media as  
30 common chocolate agar. Extracting gonococcal DNA by the  
use of base and adjusting the pH of the extract to a pH  
tolerated by the test strain with an acid results in a  
salt which is not toxic to the test strain. The  
procedures are very simple. Positive results are seen in  
35 27-40 hours without the use of a microscope. In a field

1 trial conducted in collaboration with the Centers for  
Disease Control, the method of this / <sup>invention</sup> was found to be as  
sensitive and specific as the culture technique for the  
diagnosis of gonorrhea.

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DETAILED DESCRIPTION OF THE INVENTION

I. Test Strain, N. gonorrhoeae ATCC 31953

The preferred test strain of N. gonorrhoeae for  
10 use in the method of this invention, N. gonorrhoeae ATCC  
31953 grows poorly on chocolate agar within a temperature  
range of from about 30°C to about 37°C, in a CO<sub>2</sub>  
atmosphere. Specifically, this strain barely grows in  
conditions considered to be optimum for N. gonorrhoeae  
15 i.e., on common chocolate agar, at a temperature around  
36°C in a CO<sub>2</sub> atmosphere.

This strain is also resistant to nalidixic acid  
at the 5-10 mcg/ml level and resistant to streptomycin at  
the 1000 mcg/ml level or greater. Details of the mutation  
20 and the genetic recombination procedures which resulted in  
the isolation of N. gonorrhoeae ATCC 31953 follow.

The chemical mutagen, N-methyl-N'-nitro-N-  
nitrosoguanidine, was added at a final concentration of 25  
mcg/ml to GC buffer (an aqueous solution of 1.5% peptone,  
25 such as Proteose Peptone, Difco, Detroit, Michigan, 0.028  
M potassium phosphate, dibasic and 0.007 M potassium  
phosphate, monobasic) which contained about 10<sup>9</sup> cells of  
a common laboratory strain of N. gonorrhoeae prepared from  
colony types 1 or 2 (Kellogg, Peacock, Deacon, Brown,  
30 Pirkle, J. Bacteriol. 85:1274, 1963). After a 30 minute  
incubation of the mutagen - cell suspension in a water  
bath set for 37°C, the suspension was centrifuged to  
pellet the cells. The supernate was removed to discard  
the mutagen. The pelleted cells were resuspended in GC  
35 buffer. After centrifugation a second time, the pellet

1 was again resuspended in GC buffer. The suspension was  
then plated on GC agar (in petri plates), which is GC  
medium base (GC buffer, 0.5% NaCl, 0.1% cornstarch, 1.0%  
agar) supplemented at a final concentration in gms/100ml,  
5 with glucose 0.4g, glutamine 0.01g, cocarboxylase  
0.00002g,  $\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$  0.0005g. The petri plates  
were incubated overnight at 30°C and then switched to  
37°C for the second night of incubation. Small colonies  
were picked and tested for the inability to grow  
10 luxuriously at 37°C on GC agar. A poor growing variant  
of N. gonorrhoeae judged to be potentially useful in the  
method of the invention was isolated in this manner and  
used to obtain the test strain having specific antibiotic  
resistance. The antibiotic resistance genes were  
15 introduced into this variant in the following manner.

DNA was extracted from the RW-2 strain of N.  
gonorrhoeae which contains the Nal gene conferring  
resistance to nalidixic acid at the 5-10 mcg/ml level  
(Wharton, Zubrzycki, J. Bacteriol. 127:1579, 1976). The  
20 DNA extraction procedure was accomplished by adding NaOH  
at a final concentration of 0.1N to a suspension of RW-2  
(containing approximately  $1 \times 10^8$  cells/ml) in GC  
buffer. The extract was then neutralized with HCl.

Two-tenths ml of this neutralized extract  
25 containing RW-2 DNA was added to a 1.8 ml suspension of  
the variant (about  $1 \times 10^8$  cells/ml) in GC buffer which  
contained approximately  $10^{-3}\text{M}$   $\text{CaCl}_2$ . After incubating  
the DNA-cell mixture for 30 min. in a water bath set for  
30°C, 0.1ml aliquots of the mixture were put onto, and  
30 then evenly spread on the surface of six petri dishes  
containing GC agar. After incubating the plates in a  
candle extinction jar for 4 hours, the GC agar was lifted  
from the petri dish and placed on top of another layer of  
GC agar which contained 10mcg/ml Nal. This double-layered  
35 agar, with the DNA-cell mixture on the top, was incubated

0081078

1 for about 40 hours at 30°C in a CO<sub>2</sub> atmosphere. Of  
the many colonies which appeared, presumably resistant to  
Nal, twenty were selected at random and subcultured. Of  
these, one was selected as being best suited, at this  
5 time, for use in the method of this invention.

Using essentially the same procedures as just  
described, DNA from N. gonorrhoeae strain 24392 (Maier,  
Zubrzycki, Coyle, Antimicrob. Ag. Chemo. 7:676, 1975) was  
used to introduce the Str gene into the Nal variant. Of  
10 14 isolates which were resistant to both antibiotics, Nal  
at the 5-10 mcg/ml level and Str at the 1000mcg/ml level  
or greater, one was selected as being best suited as the  
test strain for use in the method of this invention, N.  
gonorrhoeae ATCC 31953. The test strain N. gonorrhoeae  
15 ATCC 31953 has morphological and biochemical  
characteristics generally like those of Neisseria  
gonorrhoeae.

## II. Growth and Preparation of a Test Strain

20 A test strain is prepared for use in accordance  
with the method of this invention by growing it on the  
surface of GC agar at 30°C in a CO<sub>2</sub> atmosphere  
suitable for N. gonorrhoeae, for example: a candle  
extinction jar; a CO<sub>2</sub> incubator; a CO<sub>2</sub> generating  
25 system such as a Gas-Pak system (Baltimore, Biological  
Laboratories, Cockeysville, Maryland). After overnight  
incubation, areas of colony growth on the agar plates  
having mostly colony types 1 and/or 2 (Kellogg, Peacock,  
Deacon, Brown, Pirkle, J. Bacteriol. 85:1274, 1963) are  
30 harvested with sterile cotton swabs which are inserted  
into 10-20 ml volumes of GC buffer containing 10-20%  
glycerol, in order to make a suspension equivalent to a  
number 4 or 5 McFarland standard (Lennette, Spaulding,  
Truant, Manual of Clinical Microbiol., Amer. Soc.  
35 Microbiol., p. 933, 1974). Selection of colony types 1 or



1 2 is required to ensure that a test strain in a  
preparation is at the optimum state of competence, i.e.  
the state of optimum uptake of DNA which is necessary for  
transformation. Five ml volumes of this suspension are  
5 put into tubes which in turn are put into a  $-70^{\circ}\text{C}$   
freezer and stored until needed. When needed for the  
method of the invention, the suspension is thawed by  
placing the tube into a  $37^{\circ}\text{C}$   $\text{H}_2\text{O}$  bath.

A freshly prepared suspension of a test strain  
10 can also be used. In this case, the turbidity of the  
suspension can be anywhere between a quarter of a number 1  
McFarland up to a number 4. The suspending medium need  
not contain the glycerol. The frozen-thawed and the fresh  
are the preferred preparations of a test strain for use in  
15 accordance with the method of this invention.

A third alternative is to use a suspension made  
from a lyophilized preparation of a test strain. A  
suspension at a turbidity of a McFarland 5 or 6 is made in  
a medium which contains approximately: 1.5% peptone;  
20 0.04% L-glutamic acid; 5% albumin; 5% serum; 5% glycerol;  
0.2% starch; 0.4% glucose; 10% sucrose. This medium is  
adjusted with KOH to a pH of about 7.2. The suspension is  
then lyophilized.

The lyophilized preparation is reconstituted in  
25 GC buffer and used immediately or reconstituted in GC  
buffer containing the following growth supplements in  
gms/100 ml: glucose 0.4g, glutamine 0.01g, cocarboxylase  
0.00002g,  $\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$  0.0005g. In the latter  
case, the reconstituted suspension is incubated for 4-6  
30 hours at  $30^{\circ}\text{C}$  in a  $\text{CO}_2$  atmosphere before use. The use  
of the lyophilized test strain after incubation gives  
better results, i.e., more colonies in a positive test  
than the direct use of the lyophilized preparation.

While reference is made to growing a test strain  
35 on the surface of a medium containing agar, specifically

1 GC agar, this does not exclude growing a test strain on or  
in any medium. For example, a liquid culture in a flask  
or fermenter may be used. Although reference is made to  
using GC buffer with or without glycerol, this does not  
5 exclude using any other medium suitable for maintaining  
the viability of a test strain, fresh or frozen. Also  
while reference is made to the special medium in which a  
test strain is lyophilized, this does not exclude using  
any other medium suitable for lyophilizing a test strain.  
10 When a test strain is resistant to an antibiotic, this  
antibiotic can be added to any of the liquid or solid  
media used in preparing the test strain for use. For  
example, Nal at 5 mcg/ml and Str at 1000 mcg/ml were added  
to a frozen lot of the test strain, N. gonorrhoeae ATCC  
15 31953, in order to rid it of a contaminant when a lot was  
subsequently used. Now, as a precaution, these  
antibiotics are routinely added to the GC buffer with or  
without glycerol used in preparing a suspension of the  
test strain, N. gonorrhoeae ATCC 31953, and are added to  
20 the medium in which the test strain is lyophilized.

### III. The Extraction and Neutralization

The preparation of a DNA extract involves placing  
a patient's specimen material or suspect colonies into a  
25 base which lyses the gonococci and then adjusting the pH  
of the extract with acid to a pH which is not toxic to a  
test strain. A variation is to make a suspension of the  
specimen material or colonies in GC buffer and then adding  
the base and acid to that suspension. In either case, the  
30 prepared extract is generally heated. The preferred base  
and acid are NaOH and HCl.

NaOH and HCl solutions are prepared by diluting  
commercially available 10N or 1N NaOH solutions and  
37%-38% or 1N HCl solution in GC buffer. Diluting the  
35 NaOH and HCl in this buffer is an important procedure.

- 1 The buffering effect allows one to use a little more or  
less of the recommended volumes of the NaOH and HCl  
without changing the pH below 6.0 or above 8.0. This  
range of pH is tolerated by the test strain in the  
5 transformation test to be performed. KOH or even  $\text{NH}_4\text{OH}$   
can be used instead of NaOH. It is expected that any base  
can substitute for NaOH, even a weak organic base. It is  
expected that any acid can be used to offset the base,  
even weak organic acids. In each case, the principle is  
10 the same, namely, a base is used to lyse gonococci to  
release DNA, and an acid is used to adjust pH of the  
extract to a pH which is not toxic to a test strain.

The volumes of GC buffer, NaOH and HCl can vary.  
Some of the combinations which were found to be useful are  
15 as follows: 0.2-0.3 ml 0.1N NaOH and 0.3-0.4 ml 0.05N HCl;  
0.5 ml 0.1N NaOH and 0.6-0.8 ml 0.05N HCl; 0.5 ml GC  
buffer, 0.1-0.2 ml 0.5N NaOH and 0.2 ml 0.2-0.4N HCl; 0.5  
ml GC buffer, 0.1 ml 0.4N NaOH and 0.1-0.2 ml 0.2N HCl.  
The principle is to keep the volumes of GC buffer, NaOH  
20 and HCl small enough to minimize dilution of the DNA and  
yet large enough for convenient use in a routine  
laboratory situation. Again, it should be noted that GC  
buffer is not required as the suspension medium although  
it is used in the sample extraction procedure for the  
25 cervical swab specimen hereinafter described.

As an aide to seeing that the prepared DNA  
extract is near a neutral pH, phenol red at a final  
concentration of 0.005% is used in the base, acid, GC  
buffer or even all three. This does not exclude using it  
30 at any other useable concentrations. Nor does this  
exclude using other acid-base pH indicators for the  
purpose just stated.

After the base-acid extraction procedure, the  
extract is heated to  $60^{\circ}\text{C}$ - $70^{\circ}\text{C}$  for 10 min - 15 min.  
35 Temperatures as high as  $75^{\circ}\text{C}$  and time periods as long as

1 30 min. have been used without any apparent effect on the  
results. With pure cultures of N. gonorrhoeae, the  
heating step is not necessary because gonococci are very  
suceptible to treatment with a base. This is not the case  
5 with some other organisms found in mixed cultures and  
clinical specimens. Heating inactivates those organisms  
which escape treatment with a base.

As a further precaution against contamination  
during or after extracting a specimen or colonies, an  
10 antibiotic tolerated by a test strain is added to the GC  
buffer. An antibiotic can be added to the base and acid  
as well. An antibiotic can similarly be added to any of  
the media useful in accordance with the method of this  
invention. When using the test strain, N. gonorrhoeae  
15 ATCC 31953, Nal and Str are the antibiotics used at  
concentrations of 5 mcg/ml and 1000 mcg/ml, respectively.  
The concentrations of antibiotics stated does not exclude  
using these antibiotics at higher concentrations tolerated  
by the test strain.

20 Ethyl alcohol at a final concentration of about  
70% can be added to the pH adjusted DNA extract whether it  
has been heated or not. The use of alcohol may be  
preceded by an addition of about 0.01% albumin to an  
extract. The albumin acts as an inert carrier for the  
25 precipitate which occurs. The suspension is centrifuged  
at low speed to pellet the precipitate which contains DNA  
or the precipitate can be collected on filters. The  
precipitate is dissolved in a small amount of GC buffer,  
which may contain antibiotics tolerated by a test strain.  
30 The amount of GC buffer added is one-tenth to two-tenths  
the original volume, resulting in a concentrated extract.  
After about 10 minutes at room temperature, the  
concentrated extract is useable in the transformation  
step. The use of a concentrated extract usually yields  
35 more colonies in a positive test than the use of an  
extract which is not concentrated.

1 Ethyl alcohol can also be used to concentrate the  
DNA while it is being extracted by the base. In this  
case, an alcohol-base solution extracts and precipitates  
the DNA simultaneously. Again the addition of albumin is  
5 optional. The precipitate can be harvested after  
centrifugation or after collection on a filter. In both  
cases the suspending medium, GC buffer, should be at a pH  
of around 6.0 to offset any residual base in order that  
the final concentrated DNA solution would not be above pH  
10 8.0.

A virtue of using an alcohol procedure is that  
the alcohol acts as a germicide to inactivate viable  
organisms. In most situations, this would eliminate the  
need for the heating step in the extraction procedure  
15 described above.

#### IV. A Sample Extraction

A sample extraction procedure is now being  
presented. A cervical swab is put into a test tube which  
20 contains 0.5ml GC buffer. The cervical swab is mixed in  
the buffer and left in the tube for the remainder of the  
extraction procedure or, squeezed against the side of the  
tube and discarded. To the resultant suspension of mucus  
and cells is added 0.2 ml of 0.3N NaOH (containing 0.005%  
25 phenol red). After a brief time (approximately 30  
seconds) 0.2ml to 0.3ml of 0.2N HCl is added to the  
extract. The test tube is then heated for 10 minutes in a  
water bath set at 68°C. After cooling to room  
temperature, the extract is ready for the transformation  
30 step of this invention. This example does not exclude  
using rectal, urethral or other specimens. The same  
extraction procedure can be used on colonies suspected of  
being N. gonorrhoeae from pure or mixed cultures, picked  
by an applicator stick, inoculating loop, needle or any  
35 implement made of wood, plastic, metal or paper as long as

- 1 it can be used to deliver gonococci into the GC buffer or  
base solution.

V. The Transformation

- 5 The transformation step of the test method of  
this invention is carried out by applying the prepared DNA  
extract to a test strain which grows poorly at about  
36°C on or in a biological medium which can contain  
antibiotics at concentrations tolerated by the test  
10 strain. The preferred method of applying the extract to a  
test strain is by spotting it onto a lawn of the test  
strain which is prepared on a common chocolate agar  
plate. To prepare this lawn preferably two sterile cotton  
swabs held side by side are dipped into a suspension of a  
15 test strain. These swabs are then evenly smeared on the  
surface of a chocolate agar plate in a manner similar to  
that done for an antibiotic disk susceptibility test  
(Lennette, Spaulding, Truant, Manual of Clinical  
Microbiology, Amer. Soc. Microbiol., p. 423, 1974). One  
20 can use a single swab or any number of swabs, or any other  
implement or method for seeding a chocolate agar plate  
with a lawn of a test strain. Although a commercial  
chocolate agar plate (Baltimore Biological Laboratories,  
Cockeysville, Maryland) has been used in many of my  
25 studies, this does not exclude any other useable nutrient  
agar or chocolate agar whether in a petri dish, any type  
of container or on any surface. This does not exclude a  
nutrient agar or chocolate agar or any useable growth  
medium which contains antibiotics at concentrations which  
30 are tolerated by a test strain and on which the test  
strain grows poorly at a temperature around 36°C in a  
CO<sub>2</sub> atmosphere. This does not exclude a medium  
containing an ingredient which can substitute for CO<sub>2</sub>  
such as NaHCO<sub>3</sub>.

35

1           After the lawn of a test strain is spotted with  
the extract, the chocolate agar plate is incubated at a  
temperature around 36°C in a CO<sub>2</sub> atmosphere suitable  
for growth of N. gonorrhoeae. After 27-40 hours  
5 incubation, a positive test is seen as an area of colony  
growth where the extract was spotted. A negative test  
shows no area of colony growth at the spotted area.

          Although it is preferred to use a test strain in  
the form of a lawn, it is within the scope of this  
10 invention to use a test strain in any manner in which  
gonococcal DNA can be used to stimulate detectable growth  
of a test strain under conditions which are inhibitory for  
example, prohibitive temperatures. This means that the  
test could be run in a liquid environment, with or without  
15 antibiotics tolerated by a test strain, containing the  
test strain and gonococcal DNA as long as the presence of  
that DNA accounts for the growth of the test strain which  
would not take place without the gonococcal DNA.

20 VI. Supporting Data

          The efficacy of the test method in accordance  
with the method of this invention was shown in a blind  
study done in collaboration with the Centers for Disease  
Control in which the results of the method of this  
25 invention were compared to clinical culture analyses.  
Cervical and rectal specimens from women and urethral  
specimens from men were collected at a DeKalb County,  
Georgia, clinic. Two swabs were taken from each anatomic  
site: one was immediately plated on selective medium and  
30 processed at the clinic; the other was mailed to  
Philadelphia, Pennsylvania where the test in accordance  
with the method of this invention was carried out. The  
following positive (+) and negative (-) results were  
obtained:

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0081078

1	<u>METHOD OF INVENTION</u>	<u>CULTURE METHOD</u>					
		<u>CERVICAL</u>		<u>RECTAL</u>		<u>URETHRAL</u>	
		+	-	+	-	+	-
	+	69	2	26	4	74	2
5	-	2	132	1	128	2	66

With regard to the cervical specimens, 69 were positive and 132 were negative by both test methods. For the 2 cervicals which were positive by the method of this invention but culture negative, the following information is available: one cervical came from a patient who was located, retested and found to be culture positive and again positive by the method of this invention. This patient was infected with N. gonorrhoeae which is apparently vancomycin sensitive because upon retesting that patient, N. gonorrhoeae was isolated from chocolate agar and Thayer-Martin medium which contains vancomycin. Because the test in accordance with the process of this invention is independent of any characteristic of N. gonorrhoeae infecting humans, other than ability to grow at about 36°C on chocolate agar in a CO<sub>2</sub> atmosphere, the method of this invention detected this positive the first time as well as the second time. In this regard, the method of this invention could be a very valuable test for the diagnosis of gonorrhea in areas where vancomycin sensitive strains of N. gonorrhoeae are common (Windall et al., J. Inf. Dis. 142:775, 1980). The second cervical came from a patient who was a contact to gonorrhea and had a positive rectal culture. This means that the patient had gonorrhea. In this case, the rectal as well as the cervical were positive by the method of this invention.

Based on this information, a reasonable conclusion is that there are no false positive tests in accordance with the process of this invention. The test is as specific for the diagnosis of gonorrhea as is the



1 culture method. The sensitivity of the invention test for  
cervicals, i.e., the number of positives detected is the  
same as for the culture method sensitivity of 97.3%  
(71/73).

5 With regard to the rectal specimens, 26 were  
positive and 128 negative by both test methods. Of the 4  
rectals which were positive by the method of this  
invention but culture negative, all of the corresponding  
cervicals were culture positive as well as positive by the  
10 test method of this invention. Therefore these specimens  
came from patients who had gonorrhea. The four rectals in  
question were most likely false-negative cultures. Based  
on this information, the sensitivity of the method of this  
invention for rectals is 96.8% (30/31) compared to the  
15 culture method's sensitivity of 87.1% (27/31).

With regard to the urethral specimens, 74 were  
positive and 66 were negative by both test methods.  
Concerning the two urethra which were positive by the  
test method of this invention but culture negative, both  
20 specimens were strongly positive for gonococci by the gram  
strain method. Therefore, the specimens came from  
patients who had gonorrhea. The two urethra in question  
were most likely false-negative cultures. Based on this  
information, the sensitivity of the method of this  
25 invention for urethra is the same as the culture method  
sensitivity of 97.4% (76/78).

In addition to the above data, 68 patients were  
tested for cures within 14 days after gonorrhea therapy.  
The results of both test methods were the same, i.e. the  
30 specimens from the patients were negative.

The method of this invention may be suitably  
performed by the use of a test kit. The kit consists  
essentially of an aliquot of a test strain of N.  
gonorrhoeae which grows poorly at about 36°C on or in a  
35 biological medium. The kit may also include (1) a solid

0081078

1 or liquid medium capable of supporting growth of the test  
strain, (2) a supply of a base, with or without ethanol,  
(3) a supply of an acid, (4) a pH indicator and (5)  
laboratory equipment or supplies. A test strain may be  
5 provided as a fresh culture or suspension, as a frozen  
suspension, as a lyophilized or dry preparation. The  
preferred biological medium is a chocolate agar or any  
other nutritional agar in any shape or form on which a  
test strain barely grows at a temperature around 36°C in  
10 a CO<sub>2</sub> atmosphere suitable for N. gonorrhoeae.

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1 What is claimed is:

1. A preparation from a culture of the microorganism Neisseria gonorrhoeae ATCC 31953.

2. A preparation from a culture of the  
5 microorganism Neisseria gonorrhoeae ATCC 31953, said microorganism having characteristically poor growth on chocolate agar at a temperature within the range of from about 30°C to about 37°C in a CO<sub>2</sub> atmosphere  
suitable for growth of Neisseria gonorrhoeae, and said  
10 culture having specific resistance to nalidixic acid at the 5-10 mcg/ml level and streptomycin at the 1000 mcg/ml level or greater.

3. A preparation in accordance with claim 2, wherein said microorganism is competent to receive  
15 gonococcal DNA which imparts normal growth ability to the microorganism on or in a medium suitable for growth of N. gonorrhoeae at optimum N. gonorrhoeae growth conditions.

4. The method of detecting the presence of Neisseria gonorrhoeae DNA in a patients' specimen material  
20 or colonies suspected as being N. gonorrhoeae, whether in pure or mixed cultures, comprising the steps of (1) extracting DNA from the specimen or colonies by treatment with a base which lyses N. gonorrhoeae, (2) adjusting the pH of the extract of step (1) to a pH that is not toxic to  
25 a test strain of the microorganism Neisseria gonorrhoeae which has characteristically poor growth under conditions considered to be optimum for N. gonorrhoeae and is competent for transformation, (3) applying the pH adjusted extract to the test strain before or after putting it on  
30 or into a biological medium suitable for growth of N. gonorrhoeae, (4) maintaining the treated test strain on or in a medium suitable for growth of N. gonorrhoeae at optimum N. gonorrhoeae growth conditions which are inhibitory for the test strain, and (5) observing for  
35 detectable growth of the treated test strain.

0081078

1           5. The method of claim 4 wherein the pH adjusted  
extract of step (2) is heated at a temperature of from  
about 60°C to about 75°C for a time period from about  
ten minutes to about thirty minutes to inactivate  
5 remaining viable organisms prior to step (3).

6. The method of claim 4 wherein the pH adjusted  
extract is treated with ethanol to precipitate the DNA,  
which precipitate is then harvested and reconstituted in a  
small volume of a peptone containing buffer to effect a  
10 concentrated solution of DNA prior to step (3).

7. The method of claim 4 wherein the base  
comprises an ethanol-base mixture which simultaneously  
extracts and precipitates the DNA, which precipitate is  
then harvested and reconstituted in a small volume of a  
15 peptone containing buffer to effect a pH adjusted and  
concentrated solution of DNA prior to step (3).

8. The method of claim 4 wherein the base is an  
inorganic or organic base and the pH of the extract  
containing DNA is adjusted by an inorganic or organic acid.

20           9. The method of claim 8 wherein the pH  
adjustment is done in the presence of a pH indicator.

10. The method of claim 8 wherein the base is  
selected from the group consisting of NaOH, KOH or NH<sub>4</sub>OH  
and the acid is HCl.

25           11. The method of claim 8 wherein the base and  
acid are prepared in a peptone containing buffer.

12. The method of claim 4 wherein the additional  
step of preparing a test strain of the microorganism N.  
gonorrhoeae which has characteristically poor growth under  
30 conditions considered to be optimum for N. gonorrhoeae  
and is competent for transformation is done prior to step  
(3).

1           13. The method of claim 4 wherein the test  
strain is maintained as a lawn on an agar containing  
medium suitable for the growth of N. gonorrhoeae at  
optimum growth conditions for N. gonorrhoeae but  
5           inhibitory to the test strain.

          14. The method of claim 4 wherein the optimum N.  
gonorrhoeae growth conditions are a temperature of about  
36°C, a suitable CO<sub>2</sub> atmosphere and a time period of  
from about 27 to about 40 hours.

10           15. The method of claim 13 wherein the medium is  
common chocolate agar.

          16. The method of claim 15 wherein the chocolate  
agar contains an antibiotic at a concentration tolerated  
by the test strain.

15           17. The method of claim 16 wherein the chocolate  
agar contains an antibiotic selected from the group  
consisting of nalidixic acid and streptomycin.

          18. The method of claim 4 wherein the test  
strain is in a form selected from the group consisting of  
20           a culture growth, a fresh suspension from a solid medium,  
a lyophilized or dry preparation or a thawed suspension of  
a frozen stock.

          19. The method of claim 4 wherein the test  
strain is Neisseria gonorrhoeae ATCC 31953.

25           20. The method of claim 18 wherein the form of  
the test strain contains antibiotics tolerated by the test  
strain.

          21. The method of claim 4 wherein the base and  
acid contain antibiotics at concentrations tolerated by  
30           the test strain.

          22. A test kit for detecting Neisseria  
gonorrhoeae DNA consisting essentially of an aliquot of a  
test strain of Neisseria gonorrhoeae which grows poorly at  
about 36°C on or in a biological medium.

35           23. A kit in accordance with claim 22, wherein  
the test strain is N. gonorrhoeae ATCC 31953.

0081078

1           24. A kit in accordance with claim 22,  
characterized by the inclusion of one or more parts  
selected from the group consisting of (1) a solid or  
liquid medium capable of supporting growth of the test  
5 strain, (2) a supply of a base, with or without added  
ethanol, (3) a supply of an acid, (4) a pH indicator and  
(5) laboratory equipment or supplies.

10           25. Neisseria gonorrhoeae ATCC No. 31953..

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# EUROPEAN SEARCH REPORT

0081078

Application number

EP 82 10 9984

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 8)
X	--- SEXUALLY TRANSMITTED DISEASES, vol.7, October/December 1980, American Venereal Disease Association, (US) L. ZUBRZYCKI et al.: "Laboratory diagnosis of Gonorrhea by a sim- ple transformation test with a temperature-sensitive mutant of Neisseria gonorrhoeae", pages 183 to 187 * the whole article *	1-25	C 12 Q 1/04 C 12 Q 1/12 C 12 N 1/20 C 12 R 1/36 //
D, Y	--- JOURNAL OF BACTERIOLOGY, vol.127, no.3, September 1976, American Society for Microbiology, (US) R.D. WHARTON et al.: "Temper- ature-sensitive mutants of Neisseria gonorrhoeae", pages .1579 to 1581 * the whole article *	1-25	
Y	--- ABSTRACTS OF THE ANNUAL MEETING, 1975, American Society for Microbiology P. WARNER et al.: "Linking anti- biotic resistance genes of Neisseria gonorrhoeae", page 97, column 1, abstract no. H6 * * the whole abstract *	1-25	C 12 N C 12 Q C 12 R A 61 K
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 07-02-1983	Examiner ENGELBRECHT E
<b>CATEGORY OF CITED DOCUMENTS</b>			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons  & : member of the same patent family, corresponding document	

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0081078

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DOCUMENTS CONSIDERED TO BE RELEVANT			Page 2
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
A	CHEMICAL ABSTRACTS, vol.65, 1966, column 20544b, COLUMBUS, Ohio (US) P.F. SPARLING: "Genetic transformation of Neisseria gonorrhoeae to streptomycin resistance" & J. Bacteriol. 92(5), 1364-71 (1966)	2	
A	--- DIFCO MANUAL OF DEHYDRATED CULTURE MEDIA AND REAGENTS FOR MICROBIOLOGICAL AND CLINICAL LABORATORY PROCEDURES, ninth edition, Difco Laboratories, DETROIT, Michigan (US) pages 116 to 121	13, 14, 15	
A	--- DIFCO TECHNICAL INFORMATION, December 1976, Difco Laboratories, Technical Information no. 0580, DETROIT, Michigan (US) "Ready to use media for the isolation of N. gonorrhoeae or N. meningitides" -----	13-16	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int. Cl. 3)
Place of search THE HAGUE		Date of completion of the search 07-02-1983	Examiner ENGELBRECHT E
<p><b>CATEGORY OF CITED DOCUMENTS</b></p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons &amp; : member of the same patent family, corresponding document</p>			

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